Patterns of Virus Exposure and Presumed Household Transmission among Persons with Coronavirus Disease, United States, January–April 2020

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We characterized common exposures reported by a convenience sample of 202 US patients with coronavirus disease during January–April 2020 and identified factors associated with presumed household transmission. The most commonly reported settings of known exposure were households and healthcare facilities; among case-patients who had known contact with a confirmed case-patient compared with those who did not, healthcare occupations were more common. Among case-patients without known contact, use of public transportation was more common. Within the household, presumed transmission was highest from older (≥65 years) index case-patients and from children to parents, independent of index case-patient age. These findings may inform guidance for limiting transmission and emphasize the value of testing to identify community-acquired infections.

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Coronavirus disease (COVID-19) was first identified in Wuhan, China, in December 2019 (*1*). The first reported case in the United States was identified in January 2020 (*2*); by mid-March, cases had been reported in all 50 states (*3*). On March 16, 2020, the White House Coronavirus Task Force published guidance for curbing community spread of COVID-19 (*4*); soon after, states began to enact stay-at-home orders (*5*). By late May 2020, all 50 states had begun easing restrictions; reported cases reached new peaks in the summer and then winter months of 2020 (*6*,*7*). As restrictions further ease with increased availability of vaccine, and as pandemic fatigue may cause persons to adhere less consistently to recommended guidance such as masking and distancing, it may be informative to look back at exposures and within-household transmission during a period when few mitigation measures were in place. We characterized exposures common among persons with the earliest reported confirmed COVID-19 cases in the United States (onset mid-January through early April 2020) and identified factors associated with presumed household transmission.

This activity was reviewed by the Centers for Disease Control and Prevention (CDC) and was conducted consistent with applicable federal law and CDC policy. Forms were approved under the Office of Management and Budget (no. 0920–1011).

Methods

Data Source

The case investigation form (CIF; Appendix 1, https://wwwnc.cdc.gov/EID/article/27/9/20-4577-App1.

pdf) is a supplemental questionnaire designed by CDC in January 2020 to collect detailed demographic and epidemiologic information about a convenience sample of US COVID-19 case-patients reported by participating states. This purposive nonprobability sample was selected at the state level from persons identified through care-seeking, surveillance, or contact tracing as having COVID-19; infection with severe acute respiratory coronavirus 2 (SARS-CoV-2) was confirmed by reverse transcription PCR. CDC provided guidance for selection of case-patients across a range of ages and symptom severities (i.e., hospitalized and nonhospitalized), but states individually controlled sampling. The CIF was completed by state or local health department personnel or by CDC staff through case-patient or proxy interviews, along with medical record reviews (when relevant).

Case-patient demographic information included age, sex, race, ethnicity, and occupation. Workplace settings were classified according to 2012 census industry codes (Appendix 2, https://wwwnc.cdc.gov/EID/article/27/9/20-4577-App2.pdf). Clinical information included underlying conditions, symptoms, symptom onset date, dates of medical visits, and outcome (death or survival). For hospitalized case-patients, information was requested about whether the patient had been admitted to an intensive care unit, whether oxygen was received, admission and discharge dates, diagnosis, and location. Questions about exposure included whether in the 14 days before illness onset the case-patient had known exposure to a case-patient with laboratory-confirmed COVID-19 (COVID-19 contact) and, if so, the relationship and setting of the exposure. Case-patients were also asked about their exposure risks (activities and possible exposures in the 14 days before illness onset) including travel; friends, acquaintances, coworkers, or family members with fever or respiratory symptoms; close contact with (e.g., caring for, speaking with, or touching) any ill persons; attendance at a mass gathering (e.g., religious event, concert, sports event); public transportation use; attendance or work at a school or daycare; school or daycare attendance by household members; close contact with a contact of a laboratory-confirmed case-patient; close contact with someone with fever, acute respiratory illness, or both who had traveled internationally in the previous 14 days; and time in a healthcare setting as an employee, patient, or visitor.

The CIF also collected data on the case-patient's household members, defined as anyone who stayed overnight in the same residence as the case-patient during the 14 days before the case-patient's illness onset until the date of interview. Case-patients were asked for household members' age, sex, relationship to the case-patient, and whether each person had "experienced fever or respiratory symptoms (e.g., cough, sore throat, etc.) within 14 days before or after the COVID-19 patient's illness"; if yes, date of illness onset was collected. When the CIF was designed in January 2020, the most commonly reported COVID-19 signs and symptoms were fever and respiratory symptoms, and guidance for mitigation measures within households had not been widely distributed.

Analysis of Exposures

We compared exposures between those reporting known close contact with a COVID-19 case-patient in the 14 days before illness onset and those reporting no known contact. Categorical variables were compared by using χ^2 or Fisher exact tests, as appropriate. Continuous variables were compared by using *t* tests for normally distributed data and Wilcoxon rank sum tests otherwise. $p<0.05$ was considered significant. Analyses were conducted in SAS version 9.4 (https://www.sas.com) and R (https://www.r-project.org).

Analysis of Presumed Household Transmission

We separately assessed presumed household transmission by using information about household members provided by the interviewed COVID-19 case-patient (CIF subject). In the absence of SARS-CoV-2 testing data for all household members, we used reported signs and symptoms (i.e., fever or respiratory symptoms) as a proxy for symptomatic COVID-19 infection (i.e., household transmission). We analyzed households of ≥2 members (including the CIF subject) if the CIF subject had experienced ≥1 symptom (to enable identification of the first ill person [index case-patient] in the household), and symptom status was provided for ≥1 other household member. We required that the earliest symptom onset date in the household be ≥1 calendar day before symptom onset in subsequent case-patients (to limit effect of co-exposures outside the home) and that the earliest onset date in the household be ≥3 days (our median serial interval) before the interview (to allow time for symptoms to develop in exposed household members). We considered presumed household transmission to have occurred if ≥1 household member, in addition to the CIF subject, was reported as having fever or respiratory symptoms. The person with the earliest symptom onset date in a household was considered the index case-patient, regardless whether SARS-CoV-2 testing had been performed. Any members of a given household

not identified as the index case-patient are hereafter referred to as household contacts.

We calculated the overall household attack rate for symptoms as the number of symptomatic household contacts divided by the total number of household contacts with reported symptom status, with Wilson score 95% CI, and the serial interval as the time from symptom onset in the index case-patient to first symptom onset in a household contact. We investigated age and sex of the index case-patients and their contacts, household size, and relationship of the contact to the index case-patient as possible correlates of contact symptom status by using generalized estimating equation logistic regression with households as the cluster and individual symptom status as the outcome; we used an exchangeable correlation matrix and robust SEs. We excluded household contacts missing symptom status from this analysis. We examined models for collinearity and reduced if necessary. We did not include hospitalization status of the index case-patient in models because of collinearity with index case-patient age. We dichotomized contact age (<18 or ≥18 years) to avoid collinearity with familial relationship and index case-patient age.

To explore the validity of using reported symptom status to estimate household symptomatic attack rates, we calculated sensitivity and specificity by using a subset of households for which complete reverse transcription PCR and serologic testing data were available (*8*). We conducted a sensitivity analysis by reclassifying data according to a range of plausible misclassification rates (Appendix 2).

Results

Overview of the Analysis Population

Data were collected from 16 states (Alaska, Arizona, California, Connecticut, Georgia, Hawaii, Illinois, Minnesota, Pennsylvania, Rhode Island, Tennessee, Utah, Virginia, Vermont, Washington, and Wisconsin) with 202 laboratory-confirmed COVID-19 case-patients with symptom onset during January 14–April 4, 2020. Age of COVID-19 case-patients in the sample ranged from <1 to 95 years, almost all were symptomatic (195; 97%), and 1 in 3 was hospitalized for management of COVID-19 symptoms (Appendix 2 Table 3). Of the 202 case-patients, 34 (17%) reported having diabetes mellitus and 48 (24%) reported hypertension.

Exposures

A total of 82 (41%) case-patients reported known contact with a laboratory-confirmed COVID-19 case-patient in the 14 days before symptom onset. The most commonly reported exposure setting was the household (44/82; 54%); within the household setting, the most frequently reported source of COVID-19 exposure was the spouse or partner of the COVID-19 case-patient (16/44; 36%). The second most reported exposure setting was healthcare (20/82; 24%); 14 of the 20 persons exposed in the healthcare setting were healthcare workers, 4 were seeking care for unrelated medical issues, and 2 were visitors.

Among persons reporting no known COVID-19 contact, 20/84 (24%) reported having close contact with an ill person. Persons with no known COVID-19 contact worked in a variety of industries, most commonly healthcare (10/90; 11%); professional/office settings (10/90; 11%); education (9/90; 10%); and accommodation, food, or other services (9/90; 10%) (Table 1). In comparison, 28% (20/72) of persons with known COVID-19 contact reported working in healthcare. Persons with no known COVID-19 contact were significantly less likely than those with known contact to report spending time in a healthcare setting ($p = 0.004$). However, they were somewhat more likely to report travel (38% vs. 26%) or attendance at a mass gathering (36% vs. 21%) and significantly more likely to report use of public transportation (44% vs. 16%), compared with persons reporting known COVID-19 contact ($p = 0.005$)

Of the 202 case-patients, 23 (11.3%) reported no known contact with a confirmed case-patient, no travel within 14 days before illness onset, and none of the exposure risks assessed. These persons ranged in age from 21 to 88 years and were significantly older than those reporting ≥1 possible exposure (median age 52 vs. 49 years; $p<0.0001$). They required hospitalization more frequently than those reporting ≥1 possible exposure (52% [12/23] vs. 30% [54/179]; $p = 0.10$), and were significantly more likely to report ≥1 underlying medical condition (87% [20/23] vs. 58% [104/179]; $p = 0.029$). They were much more likely to report having diabetes mellitus (43% [10/23] vs. 14% [24/176]; $p = 0.002$).

Analysis of Presumed Household Transmission

A total of 69 case-patients provided data on the symptom status of ≥1 household members and were included in our household analysis; in 48 (70%) households, the CIF subject was the first or only symptomatic person in the household (i.e., was identified as the index case-patient; Figure 1). In half (34/69; 49%) of included households, ≥1 household member, in addition to the CIF subject, was symptomatic (i.e., virus transmission was presumed). Included households ranged in size

Table 1. Reported exposures of 179 COVID-19 case-patients with submitted case investigation forms by known contact with a laboratory-confirmed COVID-19 case-patient, United States, January–April 2020*

Exposure	No known contact, no. (%), n = 97	Known contact, no. (%), n = 82	p value†
Workplace setting‡			0.10
Accommodation, food, and other services§	9 (10.0)	2 (2.8)	
Construction	4 (4.4)	1 (1.4)	
Education¶	9 (10.0)	5 (6.9)	
Healthcare	10 (11.1)	20 (27.8)	
Manufacturing	2 (2.2)	1 (1.4)	
Professional or office setting	10 (11.1)	7 (9.7)	
Transportation and warehousing and utilities	8 (8.9)	3 (4.2)	
Wholesale or retail trade	3 (3.3)	7 (9.7)	
Other	7 (7.8)	6 (8.3)	
Insufficient information	5 (5.6)	6 (8.3)	
Not currently in the workforce	23 (25.6)	14 (19.4)	
Other exposure risks in previous 14 d			
Spent time in a healthcare setting			0.0044
Yes	24 (26.1)	39 (48.1)	
No	68 (73.9)	42 (51.9)	
Close contact with a contact of a confirmed case			0.0002
Yes	3 (3.6)	17 (25.4)	
No	81 (96.4)	50 (74.6)	
Attended a mass gathering**			0.07
Yes	29 (35.8)	16 (21.3)	
No	52 (64.2)	59 (78.7)	
Used public transportation			0.0048
Yes	23 (44.2)	8 (16.3)	
No	29 (55.8)	41 (83.7)	
Attended or worked at a school or daycare			1.00
Yes	8 (14.3)	7 (14.3)	
No	48 (85.7)	42 (85.7)	
Had a household member who attended school or daycare			0.51
Yes	15 (18.3)	9 (13.0)	
No	67 (81.7)	60 (87.0)	
Travel away from home			0.14
International, with or without domestic	18 (18.9)	8 (10.0)	
Domestic only	18 (18.9)	13 (16.3)	
None	59 (62.1)	59 (73.8)	

*A total of 23 persons did not know or did not report whether they had known contact with a person with laboratory-confirmed COVID-19 in the 14 d before their own illness onset. Denominators differ because some questions had incomplete responses. All complete responses are presented for each question. COVID-19, coronavirus disease.
†χ^2 or Fisher exact test.
‡Based on 2012 census industry codes. Mapping shown in Appendix 2 (https://wwwnc.cdc.gov/EID/article/27/9/20-4577-App2.pdf).
§Not including public administration services.
¶Includes persons ≥18 y of age who are pursuing higher education.
**Examples given in the questionnaire included religious event, wedding, party, dance, concert, banquet, festival, sports event, or other event.

from 2 to 16 persons (median 4 persons) and comprised a variety of household types (e.g., couples, nuclear families, roommates, multigenerational); household size and members' ages, sexes, and relationships were interrelated. Presumed transmission was more frequently observed in larger households (78% of households with ≥5 members vs. 39% of households with <5 members; p = 0.005) (Figure 2). Within households with more members, a larger number of household contacts reported symptoms (Figure 2).

Among 201 household contacts, 193 had data on symptom status, of which 62 (32%; 95% CI 26%–39%) were symptomatic. Sensitivity analysis results showed a similar plausible range of attack rates (21%–39%; Appendix 2 Results and Table 1). The median serial interval was 3 days (range 1–10 days).

Although our sample did not have large numbers of index case-patients at the age extremes, household contacts were more likely to be symptomatic if the index case-patient was <5 (5 households) or ≥65 years of age (9 households) (Figure 3, panel A); trends were similar, but the point estimates were significant only for index case-patients ≥45 years of age (vs. index case-patients 18–44 years of age) after adjustment for contact age, contact sex, household size, and relationship of the contact to the index case-patient (Table 2). Adult contacts were symptomatic more often than contacts <18 years of age (Figure 3, panel B), but this association was not significant in adjusted analyses (Table 2). The symptom status of household contacts was also associated with their relationship to the index case-patient (Table 2). Among

the contacts of 9 index case-patients <18 years of age, 11/16 (69%) parents, 6/13 (46%) siblings, and 2/5 (40%) other household contacts later became symptomatic. Among contacts of the 60 adult index case-patients, 12/44 (27%) children (range 2–49 years of age), 12/45 (27%) spouses/partners, 7/16 (44%) parents, and 11/42 (26%) other household contacts became symptomatic. When we restricted the analysis to households in which the CIF subject was the index case-patient, overall trends were similar to those reported above, but small sample sizes precluded adjusted analyses (Appendix 2 Table 2).

Illness severity of the index case-patient could not be assessed in multivariable models because of low sample size and correlation with age. However, among 12 household contacts of 10 index case-patients requiring hospitalization (three 18–44, five 45–64, and two index case-patients ≥65 years of age), only 2 were symptomwatic.

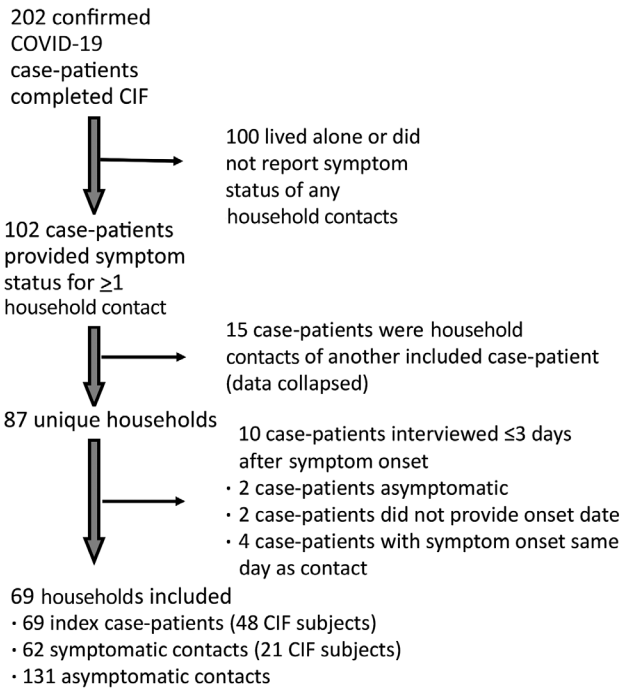

Figure 1. Households included in the analysis population for study of presumed household transmission among persons with COVID-19, United States, January–April 2020. CIF, case investigation form; CIF subject, interviewed COVID-19 case-patient; COVID-19, coronavirus disease.

Discussion

In this convenience sample of 202 early laboratory-confirmed COVID-19 case-patients, predominantly identified before widespread mitigation measures in the United States, the most commonly reported settings of known exposure were households and healthcare facilities (primarily as a workplace). Within the household, presumed transmission by age of index case-patient followed a U-shaped pattern and was significantly higher among contacts of older (≥65 years of age) index case-patients than among contacts of index case-patients 18–44 years of age. Independent of index case-patient age, parents of index case-patients were significantly more likely than other household members to report development of symptoms consistent with COVID-19.

Previous research has also found healthcare workplaces and households to be commonly reported settings of COVID-19 acquisition in the United States (*9*,*10*). In our analysis, the presumed secondary symptomatic attack rate among household members was 32%, somewhat high but consistent with estimates from previous studies, ranging from 10% to 38% (*11*–*16*; J.B. Lopez et al., unpub data, https://www.medrxiv.org/content/10.1101/2020.08.19.20177188v1). We found that presumed transmission was highest among contacts of older index case-patients (≥65 years of age), even when controlling for contact age category, relationship, and household size; however, our sample size was insufficient to control for underlying conditions or hospitalization status of the index case-patient or for detailed age category of the household contact, which may have confounded this relationship because evidence suggests that older adults are more susceptible to COVID-19 (*17*). Although results were not statistically significant in adjusted analyses, we also found that contacts of index case-patients <18 years of age (especially index case-patients <5 years of age) were more likely than contacts of index case-patients 18–44 years of age to be symptomatic. Further, symptoms were significantly more likely to develop in parents of index case-patients than in other household members. This relationship was independent of index case-patient age; however, in 8 households of adult case-patients with parental household members, 6 index case-patients were <30 years of age. Higher secondary transmission to the household contacts of younger versus adult or older COVID-19 case-patients has also been reported in analyses from the United Kingdom, South Korea, and Canada (*16*; B.J. Lopez et al., unpub. data, https://www.medrxiv.org/content/10.1101/2020.08.19.20177188v1; L.A. Paul, unpub. data, https://www.medrxiv.org/content/10.1101/2021.03.29.21254565v1). These findings may be explained by the fact that SARS-CoV-2–infected children may have similar or higher viral loads than adults (*18*) and that they may have closer interaction with family members,

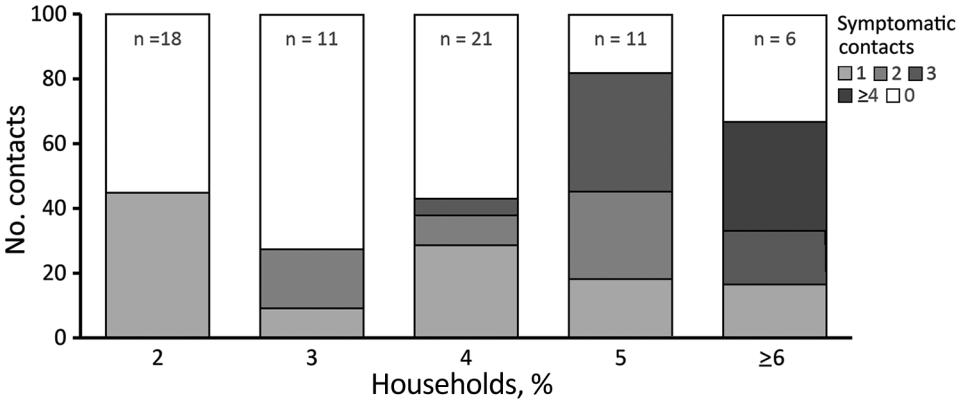

Figure 2. Proportion of households with presumed severe acute respiratory syndrome coronavirus 2 transmission, by household size (including index case-patient), United States, January–April 2020. Shading indicates percentage of households with the specified number of symptomatic household contacts (i.e., excluding index case-patient); households with zero symptomatic contacts (in white) are those in which presumed household transmission did not occur. n = no. households in each stratum.

especially parents. Parents, compared with other household members, may also play a greater role in caregiving to index case-patients, even for young adults. Conversely, in multigenerational households, adult children may act as caregivers for elderly parents, possibly exposing them before symptom onset.

A substantial proportion (60%) of case-patients in our sample did not report contact with a laboratory-confirmed COVID-19 case-patient in the 14 days before illness onset. Among case-patients without known COVID-19 contact, travel and public activities were more common, although only public transportation use was significantly higher when this group was compared with case-patients with known COVID-19 contact. Public transportation has not been identified as a major source of SARS-CoV-2 transmission (*19*–*21*), although transmission on buses, trains, and commercial flights has been reported (*19*,*22*–*26*). However, in our analysis, public transportation use might also have been more common among essential workers, those living in densely populated areas, or those with a history of travel—factors that could also increase opportunity for exposure to SARS-CoV-2 (*27*). Case-patients reporting no known source of infection, travel, or any other exposure risk factor tended to be older and to have more underlying medical conditions—particularly diabetes mellitus. Persons with concurrent conditions may be not only more susceptible to severe outcomes from COVID-19 (*28*,*29*) but also more susceptible to infection, as suggested by other analyses of SARS-CoV-2 (*8*,*30*) and Middle East respiratory syndrome coronavirus (*31*); however, more investigation is warranted.

The first limitation of our study was that the COVID-19 case-patients for whom the CIF was completed are a convenience sample of case-patients reported by 16 states during January –April 2020. Given restricted testing practices in the United States during January–March 2020, these case-patients are not representative of all US COVID-19 case-patients in terms of demographics, clinical characteristics, or exposures. Furthermore, common exposures have varied in time and geography over the course of the epidemic, and it is not possible to exclude the possibility that persons without known COVID-19 exposure had contact with an asymptomatic friend, co-worker, or

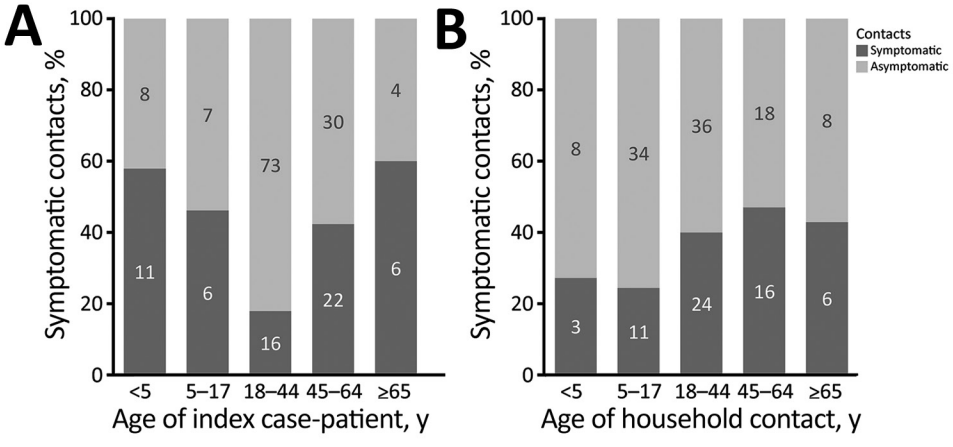

Figure 3. Symptom status of household contacts, by age group of index coronavirus disease case-patient (n = 192) and age group of household contact (n = 173), United States, January–April 2020. Age group missing for 20 contacts; age of index case-patient missing for 1 contact.

Table 2. Factors associated with symptom status of 172 household contacts of 64 symptomatic index case-patients in households with presumed COVID-19 transmission, United States, January–April 2020*

Factor	Unique households	No. with symptoms/no. total contacts (%)	aOR (95% CI)†	p value‡
Contact sex				0.73
F	50	28/85 (32.9)	Referent	
M	46	29/87 (33.3)	0.90 (0.49–1.64)	
Contact age, y				0.73
<18	25	13/50 (26.0)	Referent	
≥18	63	44/115 (38.3)	1.15 (0.53–2.47)	
Household size, persons				0.006
<5	48	23/92 (25.0)	Referent	
≥5	16	34/80 (42.5)	3.56 (1.45–8.74)	
Index case-patient age, y				0.035
<5	5	11/19 (57.9)	3.69 (0.65–20.95)	
5–17	4	6/13 (46.2)	2.09 (0.39–11.05)	
18–44	26	15/82 (18.3)	Referent	
45–64	21	20/49 (40.8)	4.61 (1.45–14.66)	
≥65	8	5/9 (55.6)	15.43 (2.28–104.17)	
Relationship of contact to index case-patient				0.070
Spouse	43	11/44 (25.0)	Referent	
Child	21	11/39 (28.2)	1.78 (0.58–5.45)	
Parent	17	18/31 (58.1)	4.55 (1.22–17.00)	
Other§	23	17/58 (29.3)	1.47 (0.42–5.11)	

*A total of 21 contacts from 5 households (i.e., 5 index case-patients) are excluded because of missing data: only relationship data for 7, only sex data for 2, only index case-patient's age for 1; only contact's age for 5, relationship and contact age for 6. Households with presumed transmission indicates households of laboratory-confirmed COVID-19 case-patients where >1 household member exhibited symptoms; index case-patient indicates household /member with first reported onset of symptoms (regardless of laboratory confirmation); household contact indicates household member of the index case-patient. aOR, adjusted odds ratio (adjusted for all variables in the table); COVID-19, coronavirus disease.
†Calculated using robust SEs.
‡Generalized Wald test.
§Includes siblings, grandparents, grandchildren, friends, and any household relationship or contact other than spouse, child, or parent.

family member. Our observed secondary attack rates (symptomatic persons) may also have been affected by the timing of the investigation because public awareness regarding measures to mitigate within-household transmission (e.g., isolation and mask-wearing within the home) was probably lower in the early stages of the US epidemic. Information was not collected on the specifics of known COVID-19 exposure, such as mask wearing or social distancing in the home or other exposure settings, because these were not common practices during survey design. The use of a convenience sample may have also affected findings regarding presumed household transmission, such as if selection were biased toward inclusion of more severe cases or larger investigations.

A second limitation is that SARS-CoV-2 infection in most household members was not laboratory-confirmed, so household members with other causes of illness could have been misclassified as COVID-19 case-patients and those with asymptomatic SARS-CoV-2 infections misclassified as non–case-patients. The possibility of misclassification of children may have been higher, given that young children frequently experience respiratory symptoms (*32*) and are less likely to show symptoms of SARS-CoV-2 infection (*33*–*35*). However, overall patterns were similar when analysis was restricted to laboratory-confirmed index case-patients, and the point estimate for odds of presumed symptomatic infection among contacts of index case-patients <5 years of age versus contacts of those 18–44 years of age was similar when contacts of unconfirmed index case-patients <5 years of age were excluded. In addition, 4 of 5 households with index case-patients <5 years of age reported that ≥1 household member attended school or daycare in the 14 days before illness onset in the CIF subject, suggesting a possible outside source of infection. Of note, similar methods are frequently used for studies of influenza (*36*), and our observed overall symptomatic attack rate and serial interval are consistent with previous knowledge of SARS-CoV-2 transmission (*37*,*38*). It is also possible that symptoms developed in some household members after the date of interview. To limit this possibility, we excluded households in which the interview took place <3 days (median serial interval in our data) after the CIF subject's symptom onset. Similarly, some presumed secondary case-patients may have actually been index case-patients or were co-exposed to the index case-patient; we tested exclusion of contacts with a 1-day lag in symptom onset and found similar trends, although the sample size precluded adjusted models. Previous research showing longer incubation periods for older patients suggests that households with older index patients would be less affected by such misclassification (*39*,*40*).

Last, our sample size was limited by state capacity for participation and data completeness. We did not have sufficient sample size to control for all possible confounders, such as index case-patient signs/symptoms, clinical characteristics, or detailed contact age category, so residual confounding is possible. The lower sample size also limited the precision of our estimates.

Our findings underline the exposure risk associated with work in a healthcare setting and within the household, as previously documented (*9*,*10*). However, most case-patients in the analysis did not have known contact with a laboratory-confirmed COVID-19 case-patient, reflecting unrecognized transmission and highlighting the need for widespread testing in addition to community mitigation measures such as masking, hand hygiene, physical distancing, and limiting nonessential travel, as well as vaccination (*41*–*43*). When going out in public, persons should take preventive actions and consider the risks associated with public activities by taking into account local orders, their ability to maintain physical distance during the activity, and whether they or their household members are at risk for severe illness from COVID-19 (*41*). Everyday preventive actions also protect at-risk household members. In this analysis, presumed household transmission was common, especially from the oldest index case-patients and from children to their parents. These findings are especially relevant to the context of in-person schooling because children exposed at schools or daycare centers may introduce COVID-19 into the home. Special care must be taken to mitigate exposure risks outside the home and to protect household members at high risk for severe COVID-19, such as older persons and those with concurrent conditions. Persons with COVID-19 should follow recommendations to reduce the risk for within-household transmission, such as staying in a separate room, wearing a mask around others, practicing hand and cough hygiene, and frequently cleaning high-touch surfaces (*44*).

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Patterns of Virus Exposure and Presumed Household Transmission among Persons with Coronavirus Disease, United States, January–April 2020

Appendix 1

COVID-19 Case Investigation Form

Reporting jurisdiction: _____ Case state/local ID: _____

Reporting health department: _____ CDC 2019-nCoV ID: _____

Contact ID a: _____ NNDSS loc. rec. ID/Case ID b: _____

a. Only complete if case-patient is a known contact of prior source case-patient. Assign Contact ID using CDC 2019-nCoV ID and sequential contact ID, e.g., Confirmed case CA102034567 has contacts CA102034567 -01 and CA102034567 -02. b. For NNDSS reporters, use GenV2 or NETSS patient identifier.

Interviewer information

Name of interviewer: Last _____

First_____

Affiliation/Organization: _____

Telephone _____ Email

_____

Date of interview: _____(MM/DD/YYYY) Date of medical chart abstraction:

_____ (MM/DD/YYYY)

Data sources used for this form?

☐ Case-patient interview ☐ Other interview, specify relationship to case:_____ ☐ Medical Chart Abstraction

Case-patient's primary language: _____ Was this form administered via a translator? □ Yes □ No □ Unknown

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Case-patient demographic information

1. Report date to CDC (MM/DD/YYYY): ____/_____/_____
2. Under what process was the case first identified? (check all that apply): ☐ PUI/sought care for acute illness ☐ Contact tracing of case patient ☐ Surveillance system, please specify:_____
   ☐ EpiX notification of travelers; if checked, DGMQID_____ ☐ Unknown
   ☐ Other, specify:_____
3. Date of birth (MM/DD/YYYY): ____/_____/_____
4. Age: _____ Age units: ☐ Years ☐ Months ☐ Days
5. Sex: ☐ Male ☐ Female ☐ Other ☐ Unknown
6. Ethnicity: ☐ Hispanic/Latino ☐ Non-Hispanic/Latino ☐ Not specified
7. Race (check all that apply): ☐ White ☐ Asian ☐ American Indian/Alaska Native ☐ Black
   ☐ Native Hawaiian/Other Pacific Islander ☐ Unknown ☐ Other, specify: _____
8. County of Residence:_____ State of Residence:_____
9. Country of Residence: ☐ United States ☐ Other, specify_____
10. Occupation:_____
    If student, what grade level? _____
    If child, does s/he attend day care? ☐ Yes ☐ No ☐ Unknown

Travel history

11. In the 14 days prior to illness onset, were you traveling away from your home internationally?
    ☐ Yes ☐ No ☐ Unknown

12. In the 14 days prior to illness onset, were you traveling away from your home within the United States?
☐ Yes ☐ No ☐ Unknown
13. Where did you travel 14 days prior to illness onset (list **ALL** locations, including overnight transits and layovers)?

	Departure Date (MM/DD/YYYY)	Departure city, state/province/country	Arrival Date (MM/DD/YYYY)	Arrival city, state/province/country
Trip 1				
Trip 2				
Trip 3				
Trip 4				
Trip 5				

Exposure history

14. In the **14 DAYS prior to illness**, did you have close contact with another lab-confirmed COVID-19 case-patient?

☐ Yes ☐ No ☐ Unknown Date Range: Start Date (MM/DD/YYYY) _____

End Date (MM/DD/YYYY) _____

15. Relationship to COVID-19 **source** case (select all that apply):
☐ Spouse/Partner ☐ Child ☐ Parent ☐ Other Family ☐ Friend ☐ HCW ☐ Co-worker
☐ Classmate ☐ Roommate ☐ Contact only – no relationship ☐ Other (specify):_____
16. Exposure setting to the COVID-19 **source** case (select all that apply):
☐ Household ☐ Work ☐ Daycare ☐ School/University ☐ Transit ☐ Rideshare ☐ Hotel ☐ Cruise Ship
☐ Healthcare ☐ Other (specify): _____

17. In the **14 DAYS prior to illness onset,** did you:

Exposure	**Answer**	**Date Range**
…have any household members, friends, acquaintances, or co-workers who had fever or respiratory symptoms (e.g. cough, sore throat etc.)?	☐ Yes ☐ No ☐ Unknown	
…have close contact (e.g. caring for, speaking with, or touching) with any ill persons?	☐ Yes ☐ No ☐ Unknown	

…attend a mass gathering (e.g., religious event, wedding, party, dance, concert, banquet, festival, sports event, or other event)?	☐ Yes ☐ No ☐ Unknown	
…use public transportation (bus, train, airplane)?	☐ Yes ☐ No ☐ Unknown	
…attend or work at a school or daycare?	☐ Yes ☐ No ☐ Unknown	
…have a household member who attended school or daycare?	☐ Yes ☐ No ☐ Unknown	
…have close contact (e.g. caring for, speaking with, or touching) with a sick person who had contact with a COVID-19 patient (i.e., secondary contact to confirmed case)?	☐ Yes ☐ No ☐ Unknown	
…have close contact (e.g. caring for, speaking with, or touching) with a person who had a fever and/or acute respiratory illness and international travel in the past 2 weeks?	☐ Yes ☐ No ☐ Unknown If yes where did the person travel:_____	

18. In the **14 DAYS prior to illness onset,** did you:

Exposure	Y/N/Unk	Facility type (Select all that apply)	Date(s) exposure occurred
Work in healthcare setting:	☐ Y ☐ N ☐ Unk If yes, what was your role: ☐ Physician ☐ Nurse ☐ Administration staff ☐ Housekeeping ☐ Patient transport ☐Other, specify_____	☐ Hospital ☐ Dialysis unit/center ☐ Urgent Care ☐ Long Term Care Facility ☐ Doctor's office/clinic ☐ Other (specify)	
Volunteer in healthcare setting	☐ Y ☐ N ☐ Unk	☐ Hospital ☐ Dialysis unit/center ☐ Urgent Care ☐ Long Term Care Facility ☐ Doctor's office/clinic ☐ Other (specify)	
Have direct patient contact	☐ Y ☐ N ☐ Unk	☐ Hospital ☐ Dialysis unit/center ☐ Urgent Care ☐ Long Term Care Facility ☐ Doctor's office/clinic	

		☐ Other (specify)	
Visit healthcare setting as a patient (not just for this illness)	☐ Y ☐ N ☐ Unk	☐ Hospital ☐ Urgent Care ☐ Doctor's office/clinic ☐ Dialysis unit/center ☐ Long Term Care Facility ☐ Other (specify)	
Visit healthcare setting for any reason other than as a patient	☐ Y ☐ N ☐ Unk	☐ Hospital ☐ Urgent Care ☐ Doctor's office/clinic ☐ Dialysis unit/center ☐ Long Term Care Facility ☐ Other (specify)	
Contact with a known COVID-19 case-patient in a healthcare setting	☐ Y ☐ N ☐ Unk If yes, as a ☐ Patient ☐ Visitor ☐ HCW	☐ Hospital ☐ Urgent Care ☐ Doctor's office/clinic ☐ Dialysis unit/center ☐ Long Term Care Facility ☐ Other (specify)	

19. Do you reside in an institutional or group setting (e.g. long-term care facility/nursing home, boarding school, college dormitory, etc.)?
☐ Yes ☐ No ☐ Unknown

20. How many people in total resided in your household (HH) from the 14 days prior to illness through the date of this interview (excluding you)? _____. *A household member is anyone with at least one overnight stay during the 14 days prior to patient's illness onset to the date of this interview. If patient belongs to multiple HH, group HH members by identifying the 1st HH as A, the 2nd HH as B, etc.*

HH (if case-patient belongs to >1 HH)	Relation to patient	Sex M/F	Age (specify unit as years, months, or days)	Did household member have fever or respiratory symptoms (e.g. cough, sore throat, etc.) in the ***14 days prior to patient's illness onset, during the patient's illness, or 14 days after patient's illness***?	Date of illness onset of household member (MM/DD/YYYY)
☐ A ☐ B ☐ C				☐ Y ☐ N ☐ Unk	
☐ A ☐ B ☐ C				☐ Y ☐ N ☐ Unk	
☐ A ☐ B ☐ C				☐ Y ☐ N ☐ Unk	
☐ A ☐ B ☐ C				☐ Y ☐ N ☐ Unk	
☐ A ☐ B ☐ C				☐ Y ☐ N ☐ Unk	
☐ A ☐ B ☐ C				☐ Y ☐ N ☐ Unk	
☐ A ☐ B ☐ C				☐ Y ☐ N ☐ Unk	

Symptoms

21. If symptomatic, onset date of first symptom (MM/DD/YYYY): ____/_____/_____ ☐ Unknown ☐ Asymptomatic
22. If experienced symptoms, are you ☐ Still symptomatic ☐ Unknown symptom status ☐ Symptoms resolved
    If symptoms resolved, date of symptom resolution (MM/DD/YYYY): ____/_____/_____ ☐ Unknown date

23. During this illness, did you experience any of the following symptoms?

Symptom		**Symptom**	
Fever ≥100.4F (38C)	☐Yes ☐No ☐Unk	Cough (new onset or worsening of chronic cough)	☐Yes ☐No ☐Unk
Highest temp_____ °F		Dry	☐Yes ☐No ☐Unk
Date of onset (MM/DD/YYYY) ___/___/_____		Productive	☐Yes ☐No ☐Unk
Duration of fever ≥100.4F (38C) (days) _____		Bloody sputum (hemoptysis)	☐Yes ☐No ☐Unk
Subjective fever (felt feverish)	☐Yes ☐No ☐Unk	Shortness of breath (dyspnea)	☐Yes ☐No ☐Unk
Chills	☐Yes ☐No ☐Unk	Wheezing	☐Yes ☐No ☐Unk
Fatigue	☐Yes ☐No ☐Unk	Chest Pain	☐Yes ☐No ☐Unk
Muscle aches (myalgia)	☐Yes ☐No ☐Unk	Abdominal pain	☐Yes ☐No ☐Unk
Rash	☐Yes ☐No ☐Unk	Vomiting	☐Yes ☐No ☐Unk
Headache	☐Yes ☐No ☐Unk	Nausea	☐Yes ☐No ☐Unk
Eye redness (conjunctivitis)	☐Yes ☐No ☐Unk	Diarrhea (≥3 loose/looser than normal stools/24hr period)	☐Yes ☐No ☐Unk
Runny nose (rhinorrhea)	☐Yes ☐No ☐Unk	Poor Feeding/Poor appetite	☐Yes ☐No ☐Unk
Sore throat	☐Yes ☐No ☐Unk	Seizures	☐Yes ☐No ☐Unk
Other, specify:	☐Yes ☐No ☐Unk	Other, specify:	☐Yes ☐No ☐Unk

Past medical history

24. Do you have any pre-existing medical conditions? ☐ Yes ☐ No ☐ Unknown

Chronic Lung Disease	☐Yes	☐No	☐Unknown	
Asthma/reactive airway disease	☐Yes	☐No	☐Unknown	
Emphysema/COPD	☐Yes	☐No	☐Unknown	
Other chronic lung disease	☐Yes	☐No	☐Unknown	(If YES, specify)
Active tuberculosis	☐Yes	☐No	☐Unknown	

Diabetes Mellitus	☐Yes	☐No	☐Unknown	
Cardiovascular disease	☐Yes	☐No	☐Unknown	
Hypertension	☐Yes	☐No	☐Unknown	
Coronary artery disease	☐Yes	☐No	☐Unknown	
Heart failure/Congestive heart failure	☐Yes	☐No	☐Unknown	
Cerebrovascular accident/Stroke	☐Yes	☐No	☐Unknown	
Congenital heart disease	☐Yes	☐No	☐Unknown	
Other	☐Yes	☐No	☐Unknown	If YES, specify:
Renal disease	☐Yes	☐No	☐Unknown	
Chronic kidney disease/insufficiency	☐Yes	☐No	☐Unknown	
End-stage renal disease	☐Yes	☐No	☐Unknown	
Dialysis	☐Yes	☐No	☐Unknown	
Other	☐Yes	☐No	☐Unknown	If YES, specify:
Liver disease	☐Yes	☐No	☐Unknown	
Alcoholic hepatitis	☐Yes	☐No	☐Unknown	
Chronic liver disease	☐Yes	☐No	☐Unknown	
Cirrhosis/End stage liver disease	☐Yes	☐No	☐Unknown	
Hepatitis B, chronic	☐Yes	☐No	☐Unknown	
Hepatitis C, chronic	☐Yes	☐No	☐Unknown	
Non-alcoholic fatty liver disease (NAFLD)/NASH	☐Yes	☐No	☐Unknown	
Other	☐Yes	☐No	☐Unknown	If YES, specify:
Immunocompromised Condition	☐Yes	☐No	☐Unknown	
HIV infection	☐Yes	☐No	☐Unknown	
AIDS or CD4 count <200	☐Yes	☐No	☐Unknown	
Solid organ transplant	☐Yes	☐No	☐Unknown	
Stem cell transplant (e.g., bone marrow transplant)	☐Yes	☐No	☐Unknown	
Cancer: current/in treatment or diagnosed in last 12 months	☐Yes	☐No	☐Unknown	
Other	☐Yes	☐No	☐Unknown	If YES, specify:
Immunosuppressive therapy	☐Yes	☐No	☐Unknown	If YES, specify:_____ _____ _____

				_____ For what condition: _____ _____ _____
Neurologic/neurodevelopmental disorder	☐Yes	☐No	☐Unknown	If YES, specify:
Other chronic diseases	☐Yes	☐No	☐Unknown	If YES, specify:

25. Current height: _____ (inches) OR _____ (cm)
26. Current weight: _____ (pounds) OR _____ (kg)
27. If female, are you currently pregnant? ☐ Yes Weeks pregnant at illness onset_____
    ☐ No ☐ Unknown
28. If female, are you postpartum (≤6 weeks postpartum)? ☐ Yes ☐ No ☐ Unknown
29. If female, are you breastfeeding? ☐ Yes ☐ No ☐ Unknown
30. If child, is he/she being breastfed? ☐ Yes ☐ No ☐ Unknown

Social history

31. Do you currently smoke cigarettes? ☐ Yes ☐ No ☐ Unknown
    If yes, how many packs of cigarettes per day? _____ For how many years? _____
32. Have you ever smoked cigarettes? ☐ Yes ☐ No ☐ Unknown
    If yes, how many packs of cigarettes per day? _____ For how many years? _____ How long since you last smoked a cigarette? ___(m) ___(y)
33. Do you currently use e-cigarettes/vape-pen? ☐ Yes ☐ No ☐ Unknown
34. In the past year, how often did you have a drink containing alcohol?
    □ Never □ Monthly or less □ 2-4 times a month □ 2-3 times per week □ 4 or more times per week

Course of Illness

35. Do you feel back to normal? ☐ Yes ☐ No ☐ Not applicable (patient deceased) ☐ Not applicable (patient asymptomatic) ☐ Unknown
    If yes, when did you feel back to normal? _____/_____/_____ (MM/DD/YYYY)
36. Did you miss work or school for this illness? ☐ Yes ☐ No ☐ Unknown
    If yes, how many days during illness? _____
37. Did you receive any medical care for the illness? ☐ Yes ☐ No ☐ Unknown
38. If yes, where and which dates did you seek care after this illness started (check all that apply)? [Please add extra visit dates in comments box]
    ☐ Doctor's office Date 1: _____/_____/_____ (MM/DD/YYYY) Date 2: _____/_____/_____ (MM/DD/YYYY)
    ☐ Emergency room Date 1: _____/_____/_____ (MM/DD/YYYY) Date 2: _____/_____/_____ (MM/DD/YYYY)
    ☐ Retail store/pharmacy Date 1: _____/_____/_____ (MM/DD/YYYY) Date 2: _____/_____/_____ (MM/DD/YYYY)

☐ Health department Date 1: _____/_____/_____ (MM/DD/YYYY) Date 2: _____/_____/_____ (MM/DD/YYYY)
☐ Urgent care Date 1: _____/_____/_____ (MM/DD/YYYY) Date 2: _____/_____/_____ (MM/DD/YYYY)
☐ Telephone triage line Date 1: _____/_____/_____ (MM/DD/YYYY) Date 2: _____/_____/_____ (MM/DD/YYYY)
☐ Other _____ Date 1: _____/_____/_____ (MM/DD/YYYY) Date 2: _____/_____/_____ (MM/DD/YYYY)
☐ Unknown

39. Was the patient hospitalized? ☐ Yes ☐ No ☐ Unknown **If YES, please fill out hospitalization section below If no, skip to Question #53**

Purpose: ☐ Clinical indication ☐ No clinical indication (e.g., isolation for public health)

Hospitalization

40. Hospital name: _____ Hospital phone: _____
41. If yes, Admission date 1 ___/___/___ (MM/DD/YYYY) , discharge date 1 ___/___/____ (MM/DD/YYYY) ☐ Patient still hospitalized
42. To where was the patient discharged?
    ☐ Home ☐ Transferred to another hospital ☐ Nursing facility/rehab ☐ Hospice
    ☐ Other _____ ☐ Unknown
43. If hospitalized more than once, please enter the second hospitalization's admission and discharge dates:
    Hospital name: _____ Hospital phone: _____
    Admission date 2 _____/_____/_____ (MM/DD/YYYY) Discharge date 2_____/_____/_____ (MM/DD/YYYY)
    ☐ Patient still hospitalized
44. To where was the patient discharged?
    ☐ Home ☐ Transferred to another hospital ☐ Nursing facility/rehab ☐ Hospice
    ☐ Other _____ ☐ Unknown
45. First recorded vital signs: Temp_____ (Unit: ☐ °F / ☐ °C) Blood pressure:
    _____ (systolic) /_____ (diastolic)
    Heart rate: _____ Resp rate:_____
    O2 Sat: _____ (Type of support required when O2 saturation was measured:
    ☐ Room Air ☐ Nasal Cannula ☐ Face Mask ☐ CPAP or BIPAP ☐ High Flow Nasal Cannula ☐ Invasive mechanical ventilation
    ☐ Other, specify: ☐ Unknown
    Fraction of Inspired Oxygen/Flow _____☐ % ☐ Liters/minute (LPM) ☐ Unknown ☐ NA

46. First recorded laboratory values for:

	Date (MM/DD/YYYY)	Value	Unit
White blood cell (WBC) count			☐ Cells x 109/L ☐ x 1 000/µL ☐ Other: _____
Absolute neutrophil count			☐ Cells x 109/L ☐ x 1 000/µL ☐ Other: _____
Absolute lymphocyte count			☐ Cells x 109/L ☐ x 1 000/µL ☐ Other: _____
Platelets (Plt)			☐ Cells x 109/L ☐ x 1 000/µL ☐ Other: _____
Aspartate transaminase (AST)			☐ U/L ☐ IU/L ☐ Other: _____
Alanine aminotransferase (ALT)			☐ U/L ☐ IU/L ☐ Other: _____
Lactate dehydrogenase (LDH)			☐ U/L ☐ IU/L ☐ Other: _____

47. Was the patient admitted to an intensive care unit (ICU)? ☐ Yes ☐ No ☐ Unknown
ICU admission date 1 _____/_____/_____ (MM/DD/YYYY) ICU discharge date 1 _____/_____/_____ (MM/DD/YYYY)
ICU admission date 2 _____/_____/_____ (MM/DD/YYYY) ICU discharge date 2 _____/_____/_____ (MM/DD/YYYY)

48. During hospitalization, did the patient receive...

		Start Date (MM/DD/YYYY)	Last Date (MM/DD/YYYY)	Total Days
Supplemental Oxygen?	☐ Y ☐ N ☐ Unk			
BiPap or CPAP use?	☐ Y ☐ N ☐ Unk			
High flow nasal cannula?	☐ Y ☐ N ☐ Unk			
Invasive mechanical ventilation?	☐ Y ☐ N ☐ Unk			
ECMO?	☐ Y ☐ N ☐ Unk			

49. Did the patient receive a discharge diagnosis of pneumonia (refer to clinical discharge summary)?
☐ Yes ☐ No ☐ Unknown

50. Did the patient receive a discharge diagnosis of acute respiratory distress syndrome (ARDS) (refer to clinical discharge summary)?
☐ Yes ☐ No ☐ Unknown

51. Clinical Discharge Diagnoses and ICD10 Discharge Codes

Clinical Discharge Diagnoses	**ICD-10-CM Code**
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	

52. Did the patient receive any antiviral medications during hospitalization for this illness:

Medication		Dose	Frequency	Start Date (MM/DD/YYYY)	Last Date (MM/DD/YYYY)	Total Days
Remdesivir	☐ PO ☐ IV ☐ IM					
Other:_____ _____	☐ PO ☐ IV ☐ IM					
Other:_____ _____	☐ PO ☐ IV ☐ IM					

Imaging

53. Was a chest x-ray taken? ☐ Yes ☐ No ☐ Unknown

54. Were any of these chest x-rays abnormal? ☐ Yes ☐ No ☐ Unknown
Date of first abnormal chest x-ray: _____/_____/_____ (MM/DD/YYYY

55. For first abnormal chest x-ray, please check all that apply: Report not available: ☐

Air space density	☐	Cannot rule out pneumonia	☐	ARDS (acute respiratory distress syndrome)	☐	Other	☐
Air space opacity	☐	Consolidation	☐	Lung infiltrate	☐	Pleural Effusion	☐
Bronchopneumonia/pneumonia	☐	Cavitation	☐	Interstitial infiltrate	☐	Empyema	☐

56. Was a chest CT/MRI taken? ☐ Yes ☐ No ☐ Unknown

57. Were any of these chest CT/MRIs abnormal? ☐ Yes ☐ No ☐ Unknown
Date of first abnormal CT/MRI: ______/_____/_______ (MM/DD/YYYY)

58. For first abnormal chest CT/MRI, please check all that apply: Report not available: ☐

Air space density	☐	ARDS (acute respiratory distress syndrome)	☐	Empyema	☐	Englarge epiglottis	☐
Air space opacity/opacification	☐	Lung infiltrate	☐	Pneumothorax	☐	Tracheal narrowing	☐
Bronchopneumonia/pneumonia	☐	Interstitial infiltrate	☐	Pneumomediastinum	☐	Ground glass opacities	☐
Consolidation	☐	Lobar infiltrate	☐	Widened mediastinum	☐	Other	☐
Cavitation	☐	Pleural effusion	☐				

Lab Results

59. SARS-CoV-2 Testing (Please report further test results in comments)

Date of sample collection (MM/DD/YYYY)	Sample Type	Result
	☐ NP ☐ OP ☐ Sputum ☐ Other, specify: ____________________	☐ Pos ☐ Neg ☐ Inconclusive
	☐ NP ☐ OP ☐ Sputum ☐ Other, specify: ____________________	☐ Pos ☐ Neg ☐ Inconclusive
	☐ NP ☐ OP ☐ Sputum ☐ Other, specify: ____________________	☐ Pos ☐ Neg ☐ Inconclusive
	☐ NP ☐ OP ☐ Sputum ☐ Other, specify: ____________________	☐ Pos ☐ Neg ☐ Inconclusive
	☐ NP ☐ OP ☐ Sputum ☐ Other, specify: ____________________	☐ Pos ☐ Neg ☐ Inconclusive

60. Was patient tested for other viral respiratory pathogens during their illness? ☐ Yes (report results below) ☐ No ☐ Unknown

	Positive	Negative	Not Tested/ Unknown	Collection Date (MM/DD/YYY)	Specimen Type
Flu A/H1	☐	☐	☐	____/____/_________	
Flu A/H3	☐	☐	☐	____/____/_________	
Flu B	☐	☐	☐	____/____/_________	
Flu (no type)	☐	☐	☐		

Respiratory syncytial virus/RSV	☐	☐	☐	____/____/_____	
Adenovirus	☐	☐	☐	____/____/_____	
Parainfluenza virus 1	☐	☐	☐	____/____/_____	
Parainfluenza virus 2	☐	☐	☐	____/____/_____	
Parainfluenza virus 3	☐	☐	☐	____/____/_____	
Parainfluenza virus 4	☐	☐	☐	____/____/_____	
Respiratory syncytial virus/RSV	☐	☐	☐	____/____/_____	
Human metapneumovirus	☐	☐	☐	____/____/_____	
Rhinovirus/enterovirus	☐	☐	☐	____/____/_____	
Human coronavirus 229E	☐	☐	☐	____/____/_____	
Human coronavirus HKU1	☐	☐	☐	____/____/_____	
Human coronavirus NL63	☐	☐	☐	____/____/_____	
Human coronavirus OC43	☐	☐	☐	____/____/_____	

61. Were any bacterial culture tests performed during their illness? ☐ Yes ☐ No ☐ Unknown

If yes, was there a positive culture for a bacterial pathogen? ☐ Yes ☐ No ☐ Unknown

If yes, specify pathogen: _____

If yes, specify date of culture (MM/DD/YYYY): _____

If yes, site where pathogen identified: ☐Blood ☐Sputum ☐Bronchoalveolar lavage (BAL) ☐Endotracheal aspirate ☐Pleural fluid

☐ Cerebrospinal fluid (CSF) ☐Other, specify: _____

If more than one bacterial culture test was performed, please record in additional comments.

Outcome

62. Did the patient die as a result of this illness?

☐ Yes, Date: _____/_____/_____ (MM/DD/YYYY) ☐ No ☐ Unknown

Where did the death occur: ☐ Home ☐ Hospital ☐ ER ☐ Hospice ☐ Other, specify_____

(If the following information is not currently available, please send an update later using death certificate or death note in hospital record.)

Contribution of COVID-19 to death ☐ Underlying/primary ☐ Contributing/secondary ☐ No contribution to death ☐ Unknown

Was autopsy performed? ☐ Yes ☐ No ☐ Unknown

Primary Cause of death (death certificate/coroner)

_____

Any additional comments or notes?

This is the end of the case investigation form. Thank you very much for your time. If you have any questions please feel free to contact the CDC at 770-488-7100 or eocreport@cdc.gov

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Patterns of Virus Exposure and Presumed Household Transmission among Persons with Coronavirus Disease, United States, January–April 2020

Appendix 2

Supplemental Methods

Workplace Setting Classification

The CIF asked participants to classify their "occupation." This free text was then processed by the National Institute for Occupational Safety and Health (NIOSH) using the NIOSH Industry and Occupation Computerized Coding System (NIOCCS) to produce 2012 Census Industry Codes. Workplace settings were categorized according to 2012 Census Industry Codes, because the CIF did not ask about occupation and industry separately. The following groups were created: accommodation, food, and other services (census industry codes 8660 – 8690 or 8770 – 9290; does not include public administration); construction (census industry code 0770); education (free text of "student" among persons ≥18 years [and census industry code 9890], or census industry codes 7860 – 7890); healthcare (reported occupation as a healthcare worker or census industry codes 7970 – 8270); manufacturing (census industry codes 1070 – 3990); professional or office setting (census industry codes 6470 – 6780 or 6870 – 7190 or 7270 – 7490); transportation, warehousing, and utilities (census industry codes 0570 – 0690 or 6070 – 6390); wholesale or retail trade (census industry codes 4070 – 4590 or 4670 – 5790); insufficient information (census industry code 9990 or unable to classify industry); not currently in workforce (retired, homemaker, unemployed, child <18 years of age); other (census industry codes not previously mentioned).

Sensitivity Analysis

A subset of 18 households included in our analysis participated in a household transmission study in Utah (*1*). Laboratory-confirmed COVID-19 case-patients were identified

by public health surveillance, and their households were enrolled within 10 days of sample collection from that initial case-patient. Nasopharyngeal (NP) and serum samples were collected from all household members at enrollment and after a 14-day follow-up period and were tested for SARS-CoV-2 by RT-PCR (NP samples) and enzyme immunoassay (serum samples). Reported household member symptom status was compared to test results (counting any RT-PCR or serology positive as a confirmed COVID-19 case patient) to calculate the sensitivity and specificity of the CIF question regarding household contact symptom status ("Did household member have fever or respiratory symptoms (e.g. cough, sore throat, etc.) in the 14 days prior to patient's illness onset, during the patient's illness, or 14 days after patient's illness?"). Misclassification-adjusted attack rates were calculated for a range of the estimated sensitivity (Se) and specificity (Sp), plus or minus 10%, in increments of 5%, using the formula (*2*):

$$Adjusted\ Attack\ Rate = \frac{Symptomatic\ contacts\ -\ Total\ contacts * (1 - Sp)}{Se - (1 - Sp)} \div Total\ contacts$$

Supplemental Results

In the subset of households for whom testing data was available on all household members (*3*), 13 of 18 test-positives were identified as symptomatic (sensitivity = 72%) and 50 of 59 test-negatives were identified as asymptomatic (specificity = 85%). The misclassification-adjusted household attack rate was 30.0% (unadjusted AR = 32.1%). The adjusted attack rates for a range of sensitivity and specificity values are shown in Appendix Table 1. The most plausible values are considered to be those estimated for Sp and Se within 5% of the calculated values and are highlighted in grey. Sample-size limitations precluded age-specific sensitivity analyses.

Reference

1. Lewis NM, Chu VT, Ye D, Conners EE, Gharpure R, Laws RL, et al. Household transmission of SARS-CoV-2 in the United States. Clin Infect Dis. 2020;ciaa1166. PubMed https://doi.org/10.1093/cid/ciaa1166

2. Lash TLFM, Fink AK. Applying quantitative bias analysis to epidemiologic data: Springer; 2009.

3. Centers for Disease Control and Prevention. COVID data tracker [cited 2021 Apr 21]. https://covid.cdc.gov/covid-data-tracker/#datatracker-home.

Appendix Table 1. Misclassification-adjusted household attack rates for varying levels of sensitivity and specificity of household case identification

	Sensitivity				
Specificity	62%	67%	72%	77%	82%
75%	19.3%	17.0%	15.2%	13.7%	12.5%
80%	28.9%	25.8%	23.3%	21.3%	19.6%
85%	36.4%	32.9%	30.0%	27.6%	25.6%
90%	42.5%	38.8%	35.7%	33.0%	30.7%
95%	47.6%	43.7%	40.5%	37.7%	35.2%

Appendix Table 2. Factors associated with symptom status of 112 household contacts of 44 laboratory-confirmed index COVID-19 case patients–United States, January – April 2020*

Factor	Unique households	N with symptoms / Total contacts (%)	Crude OR	95% CI†	p-value‡
Contact Sex					
Female	37	11 / 57 (19.3%)	1.00	-	-
Male	29	7 / 55 (12.7%)	0.57	(0.24, 1.35)	0.20
Contact Age					
<18 years	17	6 / 37 (16.2%)	1.00	-	-
18+ years	43	12 / 69 (17.4%)	0.92	(0.31, 2.79)	0.89
Household Size					
<5 people	36	9 / 70 (12.9%)	1.00	-	-
5+ people	8	9 / 42 (21.4%)	2.44	(0.63, 9.47)	0.20
Index Age					
<5 years	2	2 / 7 (28.6%)			
5 - 17 years	2	0 / 5 (0.0%)			
18 - 44 years	20	8 / 65 (12.3%)		Could not calculate	
45 - 64 years	15	7 / 30 (23.3%)			
65+ years	5	1 / 5 (20.0%)			
Relationship of Contact to Index Case					
Spouse	34	4 / 35 (11.4%)	1.00	-	
Child	16	7 / 30 (23.3%)	2.68	(0.74, 9.72)	0.20
Parent	9	5 / 17 (29.4%)	2.83	(0.51, 15.76)	
Other	13	2 / 30 (6.7%)	0.73	(0.13, 4.05)	

*60 contacts from 20 households (i.e., 20 index cases) with complete data are excluded because the index case was not the subject of the CIF (i.e., was not necessarily laboratory-confirmed as SARS-CoV-2–positive). An additional 4 contacts from 1 household (i.e., 1 index case) are excluded because the index case was not the subject of the CIF and data were missing. An additional 17 contacts from 4 households (i.e., 4 index cases) are excluded due to missing data; 2 persons missing sex, 10 missing contact age category, 11 missing relationship. Definitions: Index case – household member with first reported onset of symptoms. Household contact – household member of the index case.
Abbreviations: OR –odds ratio. CI – confidence interval. CIF – Case Investigation Form.
†Calculated using robust standard errors.
‡Generalized Wald test.

Appendix Table 3. Characteristics of 202 COVID-19 case-patients with submitted case investigation forms, United States, January 14 – April 4, 2020,

Characteristic	N (%)
Reporting Month	
January – February, 2020	23 (11.4)
March, 2020	106 (52.5)
April, 2020	73 (36.1)
Demographics	
Sex	
Female	90 (44.6)
Male	106 (52.5)
Unknown	6 (3.0)
Age (years)	
0–4	5 (2.5)
5–17	10 (5.0)
18–44	71 (35.1)
45–64	66 (32.7)
65–74	26 (12.9)
75–84	12 (5.9)
85+	5 (2.5)
Unknown	7 (3.5)
Race	
American Indian / Alaska Native	1 (0.5)
Asian	37 (18.3)
Black	12 (5.9)
Multiracial	2 (1.0)
Native Hawaiian / Other Pacific Islander	4 (2.0)
White	97 (48.0)
Other*	4 (2.0)
Unknown	45 (22.3)
Ethnicity	
Hispanic / Latino	23 (11.4)
Not Hispanic / Latino	130 (64.4)
Unknown	49 (24.3)
Behavioral History	
Smoking history	
Current	4 (2.0)
Former	31 (15.3)
Never	121 (59.9)
Unknown	46 (22.8)
Alcohol consumption	
Never	62 (30.7)
Monthly or less	25 (12.4)
At least 2x per month	38 (18.8)
Unknown	77 (38.1)
Underlying conditions	
Diabetes mellitus	
No	147 (72.8)
Yes	34 (16.8)
Unknown	21 (10.4)
Obesity (BMI ≥30)	
No	60 (29.7)
Yes	35 (17.3)
Unknown	107 (53.0)
Hypertension	
No	130 (64.4)
Yes	48 (23.8)
Unknown	24 (11.9)
Chronic respiratory condition	
No	152 (75.2)
Yes	30 (14.9)
Unknown	20 (9.9)
Renal disease	
No	167 (82.7)
Yes	14 (6.9)
Unknown	21 (10.4)
Immunosuppressive condition	
No	172 (85.1)
Yes	8 (4.0)
Unknown	22 (10.9)

Characteristic	N (%)
Clinical summary	
Symptom status	
No	6 (3.0)
Yes	195 (96.5)
Unknown	1 (0.5)
Outcome	
Deceased	6 (3.0)
Survived	158 (78.2)
Unknown	38 (18.8)
Hospitalization status	
Not hospitalized	115 (56.9)
Hospitalized for clinical management of COVID-19 symptoms	66 (32.7)
Hospitalized, unknown or other purpose (e.g., isolation)	13 (6.4)
Hospitalization unknown	8 (4.0)
Information about hospitalization†	
Discharge	
Deceased	5 (7.6)
Home	23 (34.8)
Other	2 (3.0)
Unknown	36 (54.5)
Admitted to the Intensive Care Unit	
No	26 (39.4)
Yes	34 (51.5)
Unknown	6 (9.1)
Mechanical ventilation	
No	43 (65.2)
Yes	15 (22.7)
Unknown	8 (12.1)

*All persons who indicated that none of the following racial categories applied to them: American Indian / Alaska Native, Asian, Black, Multiracial, Native Hawaiian / Other Pacific Islander, White.
†For case-patients hospitalized for clinical management of COVID-19 symptoms, N = 66.